

REMARKS

The Office Action dated May 23, 2007 has been carefully considered. Accordingly, the present Amendment is believed sufficient to place the present application in condition for allowance. Reconsideration is respectfully requested.

By the present amendment, the title of the application is revised. Additionally, claim 1 has been amended to incorporate limitations from original claims 3 and 5. Claim 1 has also been amended to recite the step of subjecting the cyclic ester to ring opening polymerization in the closed state in order to retain the over all proton concentration in a polymerization reaction system in accordance with the teachings of the specification at paragraphs [0055] and [0061]. Further, claim 1 has been amended to recite melt viscosity of the resulting aliphatic polyester as the physical property controlled by the process. Original claims 3 and 5 have been canceled from the application. Claims 21 and 22 have been added, support for which may be found in original claim 1 and in the specification, for example, at paragraphs [0051] and [0052]. It is believed that these changes do not involve any introduction of new matter, whereby entry of the amendments is believed to be in order and is respectfully requested.

Claims 1, 3-6 and 13-20 were rejected under 35 U.S.C. §103(a) as being unpatentable over Shinoda et al (US 5,412,067) in view of Howelton et al (US 5,342,918). Applicants respectfully traverse this rejection and request reconsideration of the patentability of claims 1, 3-6, and 13-20.

As defined by claim 1, the invention is directed to a process for producing an aliphatic polyester by subjecting a cyclic ester to bulk ring-opening polymerization. The process comprises providing a cyclic ester purified to the extent that a water content is at most 50 ppm, an α -hydroxycarboxylic acid content is at most 100 ppm, and linear α -hydroxycarboxylic acid oligomers content is at most 1000 ppm, and adding water to the

cyclic ester to control an overall proton concentration the cyclic ester. The overall proton concentration in the cyclic ester is calculated out on the basis of the total amount of hydroxycarboxylic compounds consisting of α -hydroxycarboxylic acid and the linear α -hydroxycarboxylic acid oligomer as impurities in the cyclic acid, water contained as impurities in the cyclic ester, and water added to the cyclic ester. The process further comprises subjecting the cyclic ester to ring opening polymerization in a closed state in order to retain the overall proton concentration in the polymerization reaction system, thereby controlling melt viscosity as the resulting aliphatic polyester.

It has been found that when an aliphatic polyester such as polyglycolic acid is produced by ring-opening polymerization of a cyclic ester such as glycolide using a high-purity cyclic ester and water is added to the cyclic ester to control the overall proton concentration in the cyclic ester, the melt viscosity and the molecular weight of the formed polymer can be precisely controlled. The overall proton concentration in the cyclic ester is determined by the amount of water and hydroxycarboxylic compounds contained as impurities and the added water. It has not previously been known that the melt viscosity and molecular weight of an aliphatic polyester can be controlled by controlling the overall proton concentration in the cyclic ester with the addition of water.

As will be discussed in detail below with reference to the Examples and Comparative Examples in the present specification, the presently claimed process allows the production of aliphatic polyesters having good, precisely controlled melt viscosity, desired molecular weight, and low yellowing.

Additionally, the presently claimed process has a number of further significant advantages. When an aliphatic polyester is mass-produced on an industrial scale, larger amount of water is used as a molecular weight control agent, so that problems from inaccurate weighing of small amounts of the added initiator are reduced. It is also possible to

strictly retain a water concentration in the polymerization reaction system, and in turn, the overall proton concentration, by using polymerization equipment in a closed system device. Further, water is inexpensive and also allows simplification and scale-down of the apparatus. When water is used as a molecular weight control agent, it is unnecessary to conduct an apparatus cleaning operation, treatment of a cleaning liquid, and the like. Thus, according to the present process, adding water, energy saving, and environmental protection can be provided. Thus, the process of the invention and the product thereof both exhibit significant improvements.

Shinoda et al disclose a polyester preparation process which includes adding a hydroxyl compound as a molecular weight regulator to a reaction system and conducting ring-opening polymerization of a cyclic ester compound. Shinoda et al teach controlling an amount of the hydroxyl compound to be added to the reaction system on the basis of the amount of free carboxylic acid contained in the cyclic ester compound (Abstract; claim 1).

Importantly, Shinoda et al neither teach nor suggest adding water or controlling the overall proton concentration in the cyclic ester which is calculated out on the basis of the total amount of hydroxycarboxylic compounds consisting of the α -hydroxycarboxylic acid and the linear α -hydroxycarboxylic acid oligomers as impurities in the cyclic ester, water contained as impurities in the cyclic ester and water added to the cyclic ester. In the Office Action, the Examiner stated that Shinoda et al disclose a polyester preparation process to obtain a desirable molecular weight (MW) from cyclic esters or their mixture, wherein impurities such as water and hydroxycarboxylic acids are accurately controlled (and thus the proton concentration is also controlled) to a total amount of less than 100 ppm in order to produce a polyester with desirable MW. However, Shinoda et al neither teach nor suggest controlling the overall proton concentration as recited in claim 1, nor adding water to control the proton concentration. That is, Shinoda et al describe that

“The cyclic ester compound used in the invention is preferably dehydrated as much as possible before subjecting to the polymerization reaction. When the moisture content is high, molecular weight control of polyester is liable to be difficult. Consequently, moisture content of the cyclic ester compound is preferably 0.5% by weight or less, more preferably 1,000 ppm by weight or less. In order to accurately control the molecular weight of polyester having a molecular weight of 100,000 or more in particular, moisture content of the cyclic ester compound is preferably 100 ppm by weight or less.” (Column 6, lines 39-50).

Thus, Shinoda et al teach that the amount of water contained as impurities in the cyclic ester is reduced as much as possible and Shinoda et al do not teach addition of water. It is error to find obviousness where references diverge from and teach away from the invention at hand, *In re Fine*, 5 U.S.P.Q. 2d 1596, 1599 (Fed. Cir. 1988). As Shinoda et al teach reducing the amount of water in the cyclic ester reactant, Shinoda et al teach away from the presently claimed process which requires adding water to the cyclic ester.

Further, Shinoda et al teach a method of controlling the amount of their added hydroxyl compound on the basis of “the amount of free carboxylic acid” contained in the cyclic ester. Shinoda et al do not teach that the amount of the hydroxyl compound to be added to the reaction system may be based on “the amount of water” and “the amount of free carboxylic acid” combined contained in the cyclic ester compound.

Typically, a cyclic ester absorbs moisture during storage or handling to change the water content. The overall proton concentration is varied by a slight difference in water content, thereby varying the melt viscosity and molecular weight of the resulting aliphatic polyester. On the other hand, in the production process according to the present invention, the amount of water and hydroxycarboxylic acids contained as impurities in the cyclic ester is exactly determined, and an amount of water, determined in view of the total proton concentration, including the amount of water (moisture) contained in an atmosphere within the container (see Example 1), is added to allow the production of an aliphatic polyester of good, controlled melt viscosity and molecular weight. However, in the process of Shinoda et al, the overall proton concentration in the cyclic ester is not calculated out on the basis of the

total amount of hydroxycarboxylic compounds and water contained as impurities in the cyclic ester. Accordingly, it is difficult to precisely control the melt viscosity of an aliphatic polyester formed in the process of Shinoda et al, as described in detail below.

The fact that water in the cyclic ester affects the molecular weight and melt viscosity of the resulting aliphatic polyester does not suggest, and in fact teaches away from using water as a molecular weight control agent. Since water is lower in molecular weight than the alcohols, hydroxycarboxylic acids and saccharides employed by Shinoda et al, its weighing accuracy is low. In addition, since the boiling point of water is lower than the ring-opening polymerization temperature, it is difficult to precisely control the water concentration in the reaction system. Further, there is no exact correlation between the water content in the cyclic ester and the melt viscosity and molecular weight of the aliphatic polyester. Accordingly, the fact that water acts as a molecular weight control agent and is excellent in practical performance cannot possibly be suggested from the prior art, and particularly by Shinoda et al, but is surprising in view of the prior art.

Shinoda et al teach the use of a higher alcohol and exemplify lauryl alcohol as the molecular weight regulator. However, the use of a higher alcohol such as lauryl alcohol involves many problems as described in the present specification and in the Applicants' previous response. For example, a higher alcohol such as lauryl alcohol is expensive and, since it is viscous, it tends to remain in a charging device (for example, a syringe) when charged into a polymerization reaction system, resulting in loss of reactant. In addition, when a higher alcohol is used in the production of an aliphatic polyester on an industrial scale, problems related to increases in the production cost are encountered, for example, (1) a large amount is required, (2) a tank and a weighing device, which are temporarily used for charging the alcohol into a polymerization reactor, are enlarged in size, (3) the apparatus which are used require additional safety measures because the alcohol is combustible, (4)

cleaning of the apparatus is required, and (5) cleaning liquids used in the cleaning of the apparatus must be treated.

Furthermore, when a higher alcohol is added to a cyclic ester, the higher alcohol is undesirably introduced into the aliphatic polyester polymer structure because the higher alcohol also acts as an initiator, and consequently the physical properties of the resulting aliphatic polyester are changed. The higher alcohol has insufficient solubility in the cyclic ester, and consequently the ring-opening polymerization reaction takes place unevenly, preventing precise control of the molecular weight and melt viscosity of the resulting polymer.

Further, when a higher alcohol as taught by Shinoda et al is used as a molecular weight control agent, the amount of the volatile matter may be somewhat reduced. However, the reduction is not sufficient for many purposes and a polymer containing a considerable amount of remaining monomer is formed. Therefore, it is difficult to precisely control the melt viscosity of the formed polymer. More specifically, it is possible to control the molecular weight (for example, weight average molecular weight) of the resulting aliphatic polyester using the higher alcohol, but since the polymer contains a relatively high amount of the remaining monomer, the melt viscosity is typically low. In this case, the melt viscosity of the polymer is affected by not only the molecular weight, but also by the amount of the remaining monomer. Additionally, when the higher alcohol is employed as a molecular weight control agent, it is difficult to reduce the yellowness index.

The Examiner's attention is directed to the Examples and Comparative Examples set forth in the present specification beginning at page 38. These Examples and Comparative Examples include a comparison which demonstrates the improvements in process and product provided by the claimed invention as compared with the exemplary teachings of Shinoda et al. More particularly, when 1-dodecyl alcohol (lauryl alcohol) as exemplified by

Shinoda et al is added as the molecular weight control agent to conduct ring-opening polymerization of glycolide as shown in Comparative Example 3 in Table 1 of the present specification (page 43), the weight average molecular weight of polyglycolic acid formed can be controlled with a measure of accuracy. However, the amount of volatile matter (residual monomer) contained in the polyglycolic acid is high, namely 0.55% by weight. Since the polyglycolic acid in Comparative Example 3 contains the volatile matter (residual monomer) in a relatively high amount, the melt viscosity thereof is markedly low (1,560 Pa·s), even though it is a high-molecular weight polymer ($M_w = 181,000$). In contrast, when water is added as the molecular weight control agent to glycolide so as to control the overall proton concentration to a predetermined value in the ring-opening polymerization as shown in Examples 1-4 in Table 1, polyglycolic acid having a desired corresponding high melt viscosity (3470-3630 Pa·s) and weight average molecular weight (205,000-218,00) can be obtained. In addition, extremely little volatile matter is contained in the polyglycolic acid (0.01-0.11% by weight).

In the Office Action, the Examiner stated that arguments directed to the amount of volatile matter are irrelevant to the claimed subject matter of claims 1 and 3-20. However, a comparison of the results of Comparative Example 3 with the results of Examples 1-4 shows that when a higher alcohol such as lauryl alcohol as exemplified by Shinoda et al is used as the molecular weight control agent (Comparative Examples), the weight average molecular weight of the resulting polymer can be controlled with a measure of accuracy, but a melt viscosity value corresponding to the value of the weight average molecular weight cannot be obtained. Rather, a low melt viscosity undesirably results. As the cause thereof, Table 1 of the present specification shows that the amount of volatile matter (residual monomer) is high in the product of the Comparative Example 3 process using lauryl alcohol, particularly as compared with the products produced by the processes of Examples 1-4, in which water is

added to control the overall proton concentration and low volatile matter results.

Accordingly, the amount of volatile matter is a measure of the unexpected improvement provided by the process of the present invention, with the desirable low volatile matter allowing better control of the melt viscosity of a resulting aliphatic polyester, in particular, allowing production of a high molecular weight aliphatic polyester having a correspondingly high melt viscosity as compared with the use of lauryl alcohol as exemplified by Shinoda et al.

Further, the results in Table 2 of the present specification (page 50) show that the amount of volatile matter in a ring-opening aliphatic polymer is high even when no water is added (Comparative Example 4). Therefore, the ring-opening polymer of Comparative Example 4 has an extremely low melt viscosity, 1,500 Pa·s, though it has the same weight average molecular weight (198,000) as the ring-opening polymer of Example 6 produced by adding water. However, the melt viscosity of the ring-opening polymer of Example 6 is 2,550 Pa·s, and it is apparent in view of the results of Examples 5, 7 and 8 that a good melt viscosity value corresponding to the weight average molecular weight value is attained according to the presently claimed process.

In the Office Action, the Examiner asserted that it will be reasonable to believe that other properties as viscosity any yellowness index will be substantially the same and that the burden shifts to Applicants to provide facts to the contrary (page 3). The Examiner's comments appear to assert that the properties recited in claims 17-20 would be inherent in the combination of Shinoda et al and Howelton et al. However, the view that success would have been inherent cannot substitute for a showing of reasonable expectation of success; inherency and obviousness are entirely different concepts, *In re Rinehart*, 189 U.S.P.Q. 143, 148 (CCPA 1976). Accordingly, the Examiner's assertions of inherency are irrelevant to the issue of the patentability of claims 17-20 under 35 U.S.C. §103.

Moreover, although Applicants submit that the Examiner has not established a prima facie case of obviousness based on Shinoda et al, even in view of Howelton et al, the showings set forth in the Examples and Comparative Examples, of the present application rebut any prima facie case of obviousness established by the Examiner. That is, the results of Examples 1 to 4 in Table 1 and 5 to 8 in Table 2 of the present specification, according to the process of the present invention, show ring-opening polyglycolic acids having the intended melt viscosity can be obtained by adding water as claimed. In addition, Examples 7 and 8 particularly show a tendency to remarkably improve the yellowness index (YI), even in a region wherein the melt viscosity and weight average molecular weight are relatively low, when water is used as the molecular weight control agent. A ring-opening polymer low in both melt viscosity and yellowness index (YI) is desirable for use as a polymer for injection molding. Finally, Comparative Example 3 in Table 1 of the present specification shows that the yellowness index (YI) of the ring-opening polymer formed when lauryl alcohol is added as the molecular weight control agent is high compared with that of the ring-opening polymers (Examples 6 and 7 in Table 2) each having a similar weight average molecular weight.

When an applicant demonstrates substantially improved results and states that the results were unexpected, this should suffice to establish unexpected results in the absence of evidence to the contrary, *In re Soni*, 34 U.S.P.Q. 2d 1684, 1688 (Fed. Cir. 1995). The Examples and Comparative Examples set forth in the present specification demonstrate substantially improved results provided by the process according to the present invention, Applicants have stated that the results were unexpected, and the Examiner has not provided any evidence to the contrary. Thus, Applicants have rebutted any prima facie case of obviousness based on Shinoda et al.

The unexpected improvements in melt viscosity, molecular weight and yellowness index control in the aliphatic polyesters produced by the process of claim 1 are not suggested from the teaching of Shinoda et al, and the deficiencies of Shinoda et al are not resolved by the teachings of Howelton et al. That is, Howelton et al disclose a process for producing carboxyl-terminated polyamides by the reaction of cyclic lactams and amino acids and teach the addition of water as an initiator for the reaction. However, a polyamide as taught by Howelton et al and the aliphatic polyesters which are the subject of Shinoda et al and the present invention are entirely different polymers. A person of ordinary skill in the art would have had no motivation, absent the present specification, to use technical features relating to the synthesis of Howelton et al's polyamide in the production process of an aliphatic polyester as taught by Shinoda et al.

Moreover, as described above, Shinoda et al teach that the cyclic ester compound is preferably dehydrated as much as possible before the polymerization reaction. Thus, Shinoda et al positively exclude a process as presently claimed in which water is added to the reaction system of the ring-opening polymerization of the cyclic ester. Accordingly, a person of ordinary skill in the art would have had no motivation to combine the teachings of Shinoda et al with the teachings of Howelton et al.

The Examiner's effort to establish obviousness by showing that the addition of water may be found somewhere in the prior art, namely in the polyamide production of Howelton et al, is unavailing; in determining obviousness, the inquiry is not whether each element existed in the prior art, but whether the prior art made obvious the invention as a whole for which patentability is claimed. *Grain Processing v. American Maize*, 5 U.S.P.Q. 2d 1788, 1793 (Fed. Cir. 1988). Not only do Howelton et al fail to teach the addition of water to a cyclic ester, Howelton et al fail to teach or suggest improvements provided by the present process in

controlling the melt viscosity of aliphatic polyesters. Accordingly, the cited prior art does not make the present invention as a whole obvious.

It is therefore submitted that the processes defined by present claims 1, 4 and 6-20 are nonobvious over and patentably distinguishable from the cited combination of Shinoda et al and Howelton et al, whereby the rejection under 35 U.S.C. §103 has been overcome.

Reconsideration is respectfully requested.

Claims 7-9 were rejected under 35 U.S.C. §103(a) as being unpatentable over Shinoda et al in view of Howelton et al, and further in view of Early et al (US 6,437,565). The Examiner relied on Early et al as disclosing the use of regression analysis in order to determine physical properties of a composition.

Applicants respectfully traverse this rejection and reconsideration is respectfully requested. The deficiencies in the combination of Shinoda et al in view of Howelton et al are discussed in detail above. Particularly, the combination of Shinoda et al and Howelton et al neither teaches nor suggests addition of water to a cyclic ester as required in claim 1 or a process wherein the melt viscosity of an aliphatic polyester is controlled by controlling the overall proton concentration in the cyclic ester, as recited in claim 1 of the present application. Further, the combination of Shinoda et al and Howelton et al neither teaches nor suggests that a certain relational expression is established between the overall proton concentration in the cyclic ester and the melt viscosity of the aliphatic polyester. The fact that such a relational expression is established was clarified for the first time by the experimental results of the present inventors.

Early et al similarly fail to teach that a certain relational expression is established between the overall proton concentration in the cyclic ester and the melt viscosity of the aliphatic polyester. In view of this deficiency in the teachings of Early et al, Shinoda et al and Howelton et al, the combination of these references provides no motivation to one of

ordinary skill in the art to add water to the cyclic ester on the basis of a relational expression between a predetermined overall protein concentration in the cyclic ester and a melt viscosity of the aliphatic polyester. Accordingly, there is simply no basis for one of ordinary skill in the art to employ any of the steps of claims 7-9 in view of the cited references.

In order to render a claimed invention obvious, the prior art must enable one skilled in the art to make and use the claimed invention, *Motorola, Inc. v. InterDigital Tech Corp.*, 43 U.S.P.Q. 2d 1481, 1489 (Fed. Cir. 1997). As none of Shinoda et al, Howelton et al and Early et al provide any teaching or suggestion of a relationship between the overall proton concentration in the cyclic ester and the melt viscosity of the resulting aliphatic polyester, one of ordinary skill in the art would not be enabled to conduct the production processes of claims 7-9 based on the combination of the teachings of these references asserted by the Examiner. Thus, the cited prior art does not enable one skilled in the art to practice the claimed invention and therefore does not render the processes of claims 7-9 obvious.

It is therefore submitted that the processes defined by present claims 7-9 are nonobvious over and patentably distinguishable from the cited combination of references, whereby the rejection under 35 U.S.C. §103 has been overcome. Reconsideration is respectfully requested.

Claims 10-12 were rejected as being obvious and unpatentable over Shinoda et al in view of Howelton et al and further in view of the *Handbook of Thermoplastic Polymers*, Chapter 2, pages 80-94 (HTP). The Examiner asserted HTP discloses a ring-opening polymerization process can be conducted in a closed volume because the process does not require evacuation of byproducts, referring to pages 90-94 of HTP.

Applicants respectfully traverse this rejection, and reconsideration is respectfully requested. The deficiencies in the combination of Shinoda et al and Howelton et al are discussed in detail above and are not resolved by HTP. That is, neither Shinoda et al nor

Howelton et al, nor a combination of these references, teach or suggest addition of water to a cyclic ester as required in claim 1 or a process wherein the melt viscosity of an aliphatic polyester is controlled by controlling the overall proton concentration in the cyclic ester, as required in claim 1.

Further, the ring-opening polymerization of the cyclic ester as recited in claim 1 is performed in a closed state so that the overall proton concentration in the cyclic ester is prevented from changing by mixing of water (moisture) in an external atmosphere. In order to precisely control the melt viscosity of the aliphatic polyester according to the process of the present invention, it is necessary to strictly control the polymerization reaction system in such a manner that the overall proton concentration, including the added water, is retained to a predetermined value. In contrast, HTP only states a general theory as to ring-opening polymerization and does not suggest the fact that the overall proton concentration, including the amount of added water, in the cyclic ester should be precisely controlled by conducting the polymerization reaction system in a closed state.

Additionally, at pages 90-94 referred to by the Examiner, HTP describes ring-opening polymerizations for polycaprolactone and polylactide production. Importantly, on page 94, HTP discloses that the cyclic dimer will contain neither water nor linear oligomers for production of polylactide. Thus, HTP similarly teaches away from water addition. Further, while HTP indicates that the lack of volatile byproducts eliminates the requirement for a vacuum, Applicants find no teaching that the reaction should be conducted in a closed system as presently claimed, and Applicants particularly find no teaching or suggestion of the specific process steps and apparatus as recited in claims 10, 11 and 12. Thus, the combination of Shinoda et al, Howelton et al and HTP does not result in processes as defined by claims 10-12 and does not enable one of ordinary skill in the art to conduct the claim

processes. Accordingly, the combination of these references does not render the processes of claims 10-12 obvious, *Motorola, Inc. v. InterDigital Tech Corp., supra*.

It is therefore submitted that the processes for producing an aliphatic polyester defined by claims 10-12 are nonobvious over and patentably distinguishable from the cited combination of references, whereby the rejection under 35 U.S.C. §103 has been overcome. Reconsideration is respectfully requested.

It is believed that the above represents a complete response to the Official Action and places the present application in condition for allowance. Reconsideration and an early allowance are requested.

Please charge any fees required in connection with the present communication, or credit any overpayment, to Deposit Account No. 04-1133.

Respectfully submitted,

/Holly D. Kozlowski/

Holly D. Kozlowski, Reg. No. 30,468
Dinsmore & Shohl LLP
1900 Chemed Center
255 East Fifth Street
Cincinnati, Ohio 45202
(513) 977-8568

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